UNCLASSIFIED

PA30,106

AD 653 126

A FUZE-TELEMETRY ANTENNA-TRANSMITTER

Howard Bassen

Harry Diamond Laboratories
Washington, D.C.

February 1967

UNCLASSIFIED

Rec'd 10-23-67 DDC

NOTICE TO DEFENSE DOCUMENTATION CENTER USERS

This document is being distributed by the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, as a result of a recent agreement between the Department of Defense (DOD) and the Department of Commerce (DOC).

The Clearinghouse is distributing unclassified, unlimited documents which are or have been announced in the Technical Abstract Bulletin (TAB) of the Defense Documentation Center.

The price does not apply for registered users of the DDC services.

AD 653126

AD

TR-1343

A FUZE-TELEMETRY ANTENNA-TRANSMITTER

by

Howard Bassen

February 1967

U.S. ARMY MATERIEL COMMAND
HARRY DIAMOND LABORATORIES
WASHINGTON, D.C. 20438

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

AD

AD653 126

DA-1N222901A301
AMCMS Code: 5221.11.62500
HDL Proj 56500

TR-1343 fac no

A FUZE-TELEMETRY ANTENNA-TRANSMITTER title

by

Howard Bassen author

February 1967 date

U.S. ARMY MATERIEL COMMAND
HARRY DIAMOND LABORATORIES fac.
WASHINGTON, D.C. 20438 abs. next page

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CONTENTS

PRECEDING PAGE BLANK

ABSTRACT

An integrated antenna-transmitter was developed to telemeter data from in-flight artillery fuzes with minimum modification of either fuze or shell. The strip transmission line antenna provides a wide, uniform radiation pattern while providing stability to a rugged and easily fabricated VHF transmitter. Incorporation of the antenna as the tuned circuit of the oscillator stage of this FM transmitter proved to be the optimum utilization of this compact ring antenna.

1. INTRODUCTION

In an effort to produce an artillery fuze telemetry system which would not require major modifications of either fuze or shell, a quarter wavelength VHF ring antenna was developed by the author (ref 1). Figure 1 shows this antenna mounted on a shell, and graphically illustrates how size, space, and location problems are overcome.

A reliable, inexpensive, and easily reproducible RF transmission system, utilizing this antenna, is the subject of this report. The antenna's high-Q properties are used to enhance the stability and reliability of the system.

The conventional approach of treating the antenna and transmitter as separate systems, which must be precisely and individually matched, was found to be unnecessarily complex. With a separate, narrowband antenna, a transmitter must incorporate stages of output buffering, thus implying many tuned matching stages, each with selected or variable components. Stability over wide temperature ranges implies that both antenna and transmitter be temperature insensitive. Even more perplexing is the variation of component parameters, especially those of the active devices. A gun-rugged environment of as much as 30,000 g creates several design restrictions because of the necessary encapsulation of the electronics. Encapsulation materials of sufficient mechanical strength have a dielectric loading effect that complicates RF design as the number of tuned circuits increases. While several RF adjustments are common in most RF circuitry, none may be used in the gun-launched environment without laborious multiple encapsulation and readjustment operations. From previous experience, one can realistically assume that every antenna and transmitter must be tediously tuned and matched. This creates a severe drawback for economical production when technical supervision is not readily available.

In contrast with the "separate system" approach is the integrated RF system approach. The high-Q antenna can be used as the radiating tuned circuit of a single-stage oscillator. Automatic

1. Bassen, H. and Jantz, R., "Telemetry Ring Antenna," TR-1335, Harry Diamond Laboratories, December 1966.

PRECEDING PAGE BLANK

tracking of changes in antenna and active-device parameters are assured because only one tuned circuit exists. The single-stage oscillator can be designed so that component and active-device variations are insignificant, thus enabling the practical fabrication of a simple, reliable, and reproducible RF transmission system.

2. ANTENNA

The quarter-wave antenna (ref 1) can be analyzed as a quarter-wavelength, shorted-termination, strip transmission line. When excited at its resonant frequency, a wide variety of real impedance values may be realized at the antenna input depending upon the driving point selected. The area near the shorted end of the stripline represents an area of low impedance. The high impedance available at the input (open) end is transformed to a lower value as a function of the ratio of total stripline length to tap point length (measured from the termination).

When this antenna was first analyzed, the antennas under study were driven at the 50-ohm point since this value was most compatible with laboratory RF equipment. It was found that the losses of the dielectric ring on which the antenna was plated were directly related to bandwidth. An epoxy fiberglass antenna had a bandwidth (VSWR of 2:1) of approximately 5 MHz at a center frequency of 227 MHz while a PPO (high temperature plastic) unit had a bandwidth of slightly over 1 MHz. The loss tangent of epoxy fiberglass is approximately .017 at 300 MHz while the loss tangent of PPO is approximately .0016. Implied by these observations is the fact that dielectric losses represent a significant portion of the real impedance of the antenna, thus directly reducing the Q of the device. Antenna patterns in figure 2 illustrate the wide, uniform pattern coverage of 120 deg in the elevation plane (3-dB points) and a highly circular azimuthal plane pattern. The patterns are those of a PPO antenna driven as the tuned circuit of a 400-mW, 250-MHz transmitter. A lumped capacitance, machined in the antenna's open end, provides a means for establishing a specific operating frequency with a fixed diameter ring. A higher dielectric material such as epoxy fiberglass would not require a lumped capacitance to bring an antenna of the same size to the same resonant frequency, but PPO was found more desirable from a mechanical standpoint.

The flexibility of design with this type of antenna is graphically illustrated in figure 3. Pictured are several units all operating at a center frequency of 238.7 MHz, with resonance characteristics being controlled by either dielectric loading, lengthening of the stripline by geometric means, or a lumped capacitance. While most units have a radiation pattern very similar to those in figure 2, the transverse ladder configuration illustrated in figure 3 provides a highly directional, rearward-

looking elevation pattern as shown in figure 4. All units provided radiated signal strengths of approximately 13 to 18 dB below a standard dipole, a figure judged quite adequate in comparison with other VHF radiators of similar size.

3. TRANSMITTER

The high-stability transmitter was first designed using adjustable coaxial transmission lines. This oscillator was then translated into a lumped parameter circuit. In this manner, an optimum efficiency value was established under the exact operating conditions desired; i.e., large signal or dynamic parameters. The best emitter and collector input admittances were then measured for a grounded-base oscillator utilizing a 2N3553 VHF transistor (fig. 5). These parameters closely represent the optimum, large-signal circuit values at the exact DC operating conditions required. A 13-V, negative-ground, DC supply was available, and a maximum current of 100 mA was decided upon because of the battery size limitations. Since the antenna was to be the resonant collector circuit, a driving point on the antenna was determined so that its input impedance would very closely approximate the measured collector load previously determined on the coaxial oscillator. The quarter-wave ring antenna was found to be ideal for this design approach. It was found to be readily adaptable due to its wide range of input impedances. By selecting the proper driving point, a high-Q tuned circuit of the proper impedance was available without additional tuned matching networks which would complicate an otherwise simple design.

An equivalent lumped-parameter circuit was then designed. Figure 6 illustrates this circuit schematically, while figure 7 shows hardware. The lumped parameter circuit was evaluated by the substitution of the coaxial oscillator's output circuitry for the antenna. Measurements indicated performance as follows:

DC supply	13 V at 75 mA
Power out	350 mW
Frequency	258 MHz

A second check was thus provided since these results confirmed a successful transition from distributed- to lumped-parameter circuitry.

Ten units were constructed using printed circuit boards with standard components and transistors; all operated within approximately one percent of the center frequency of 252 MHz and exhibited virtually no performance changes from pre-encapsulation to the final epoxy-encapsulated assembly. A heat sink was incorporated in the final assembly to provide reliability and thermal stability and to facilitate uniform assembly.

Temperature and supply voltage variations and their effect on transmitter performance were studied. Table I shows the

excellent frequency and current stability over the military temperature range. No attempts were made to temperature-compensate the transmitter other than the use of standard biasing and feedback techniques incorporating only standard resistors. The only area in which frequency and DC stability changed moderately was in the low temperature region. Since the nicad batteries to be utilized in the fuze telemetry system are inoperable at subzero temperatures, temperature compensation in this region was postponed until better power supplies become available. The fuze telemetry system was designed to accept a plug-in fuze, the fuze being independently temperature conditioned. The PPO antenna dielectric was selected partially because of the temperature insensitivities of its electrical parameters. Table II illustrates the insensitivity of oscillator frequency to supply voltage changes. A voltage regulator was added to the lid of the transmitter to provide uniform modulation sensitivity during varying supply voltages. The frequency shifts due to proximity loading effects were found to be nonexistent for distances of more than several centimeters from the ring antenna. This factor is of great significance when data from a fuze near impact is required, as is usually the case.

4. FIELD TESTS

First operational tests were carried out on an 81-mm mortar fuze. Test firings were performed over the extremes of range for this weapon. A central receiving station was used for a series of minimum range flights, where flights of 13 sec and 3000 ft occurred after an initial acceleration of approximately 1000 g. A stationary helical receiving antenna yielded complete telemetry coverage from launch to impact with a received signal of at least 20 dB above minimal receiver requirements. For maximum range flights of 12,000 ft and 40 sec, two receiving stations were used. Telemeters experienced force levels of 10,000 g and reached an altitude of 5000 ft during these flights. Complete coverage was obtained, but because of low level interference caused by trees, a second receiving station near the impact point was needed to maintain a 20-dB receiver margin. Telemetry units which were accessible (short range flights) were recovered and found to be in good working order. These units were fired several times without difficulty.

5. INTEGRATED ANTENNA-TRANSMITTER

As a further refinement of the fuze telemetry transmitter, a successful effort was made to insert the electronic rf assembly within the antenna ring. A cutout of 7/16 x 1½ x 1/10 in. was placed on the inner surface of the PPO antenna under the open end. A lumped capacitance, very similar to the one incorporated in the earlier ring antenna, resulted. No noticeable degradation of antenna performance was encountered. Circuit modifications were necessary due to the use of a flat pack 2N3866 transistor. Figure 8 illustrates the integrated antenna-transmitter assembly, while figure 9 shows the circuit schematically. Preliminary tests indicated equal or superior radiated power is possible from this unit due to a more efficient transistor. With this integrated configuration, the goals of the fuze telemetry transmitter are truly met.

6. CONCLUSION

An integrated antenna-transmitter was developed and fabricated to fulfill the need for a compact telemetry system which could be mounted on standard artillery fuze hardware. The unit operated very satisfactorily in field tests, providing reliable transmitted data without interfering with fuze performance. Low cost and easy fabrication are maintained while good performance over the intended fuze test conditions is assured.

Table I. Temperature Evaluation of the Fuze Telemetry Transmitter

Temperature (°F)	Frequency (MHz)	Supply Current (mA)	ΔF (percent)
-40	258.1	72	-
+75	258.0	84	-0.04
+165	259.0	50	+0.36

Table II. Effects of Supply Voltage on Center Frequency

Voltage (V)	Frequency (MHz)	ΔF (percent)
4.0	258.25	+0.1
13.0	258.00	-
20.0	257.75	-0.1

BLANK PAGE

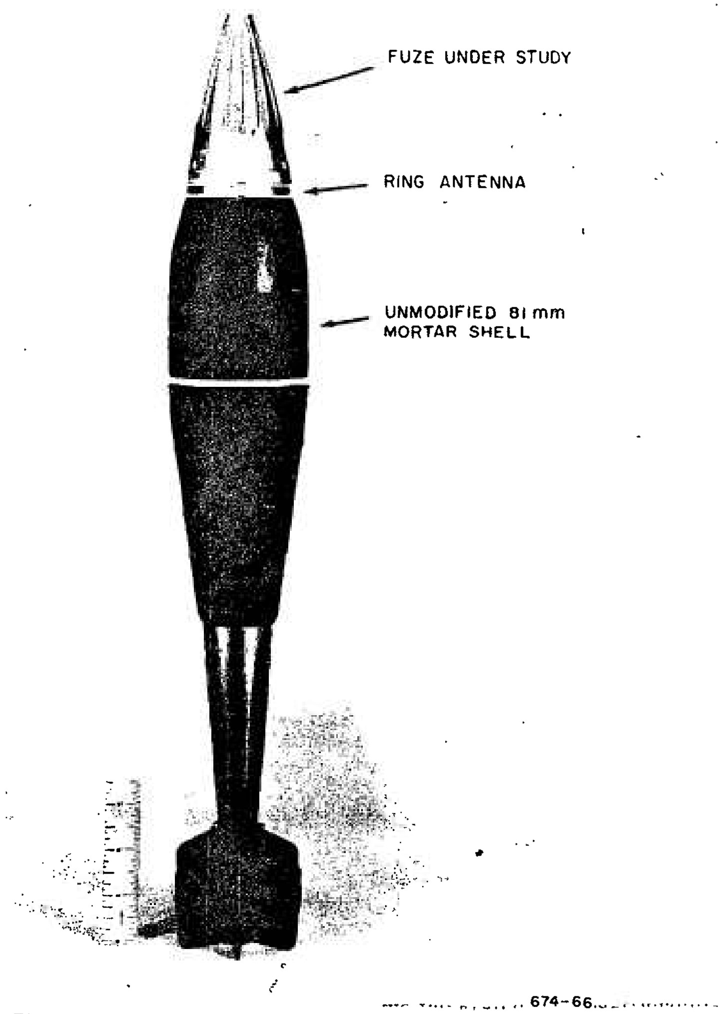
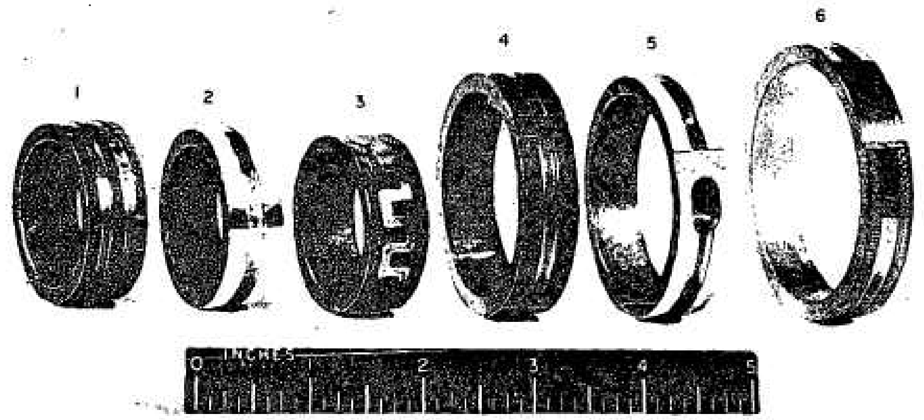


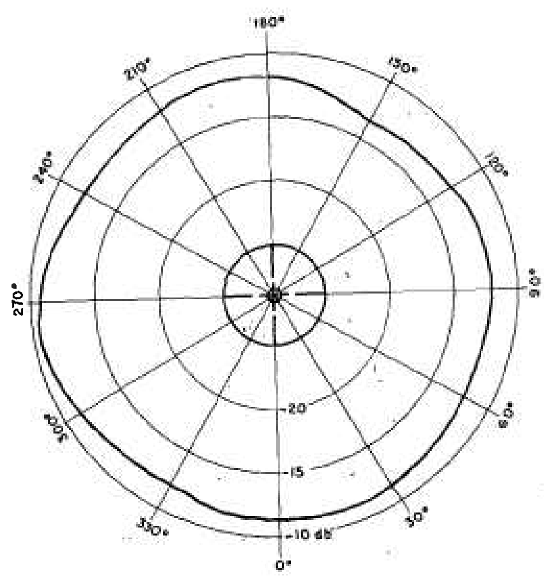
Fig. 1 Ring Antenna Mounted on 81-mm Mortar Shell.



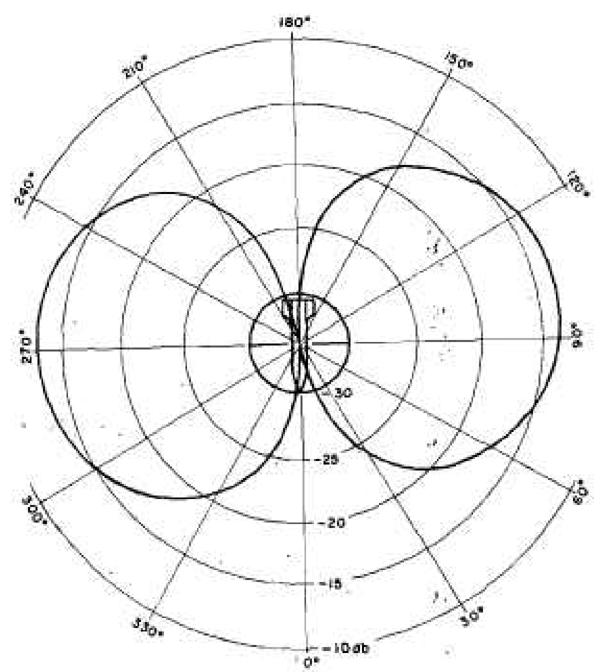
2106-66

1. Double Ring
2. Dielectrically Loaded
3. Transverse Ladder
4. Epoxy Fiberglass 2.40" I.D.
5. PPO With Lumped Capacitor
6. Epoxy Fiberglass 2.75" I.D.

Fig. 3. Fuze Telemetry Antennas Operating at 215 to 265 MHz.



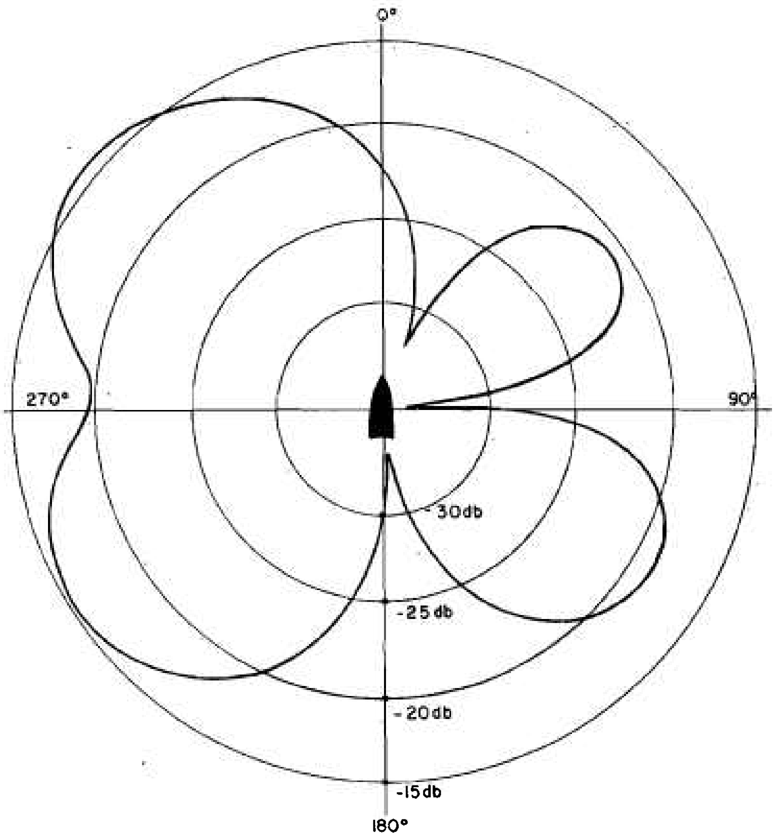
PROJECTILE VERTICAL



PROJECTILE HORIZONTAL

STANDARD DIPOLE = 0 DB

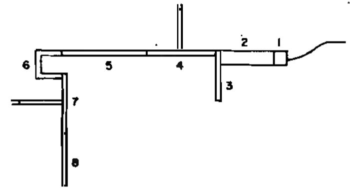
FIGURE 2 — FIELD STRENGTH PATTERNS FOR QUARTER WAVE RING ANTENNA AT 227 MHz MEASURED WITH HELICAL RECEIVING ANTENNA



NOTE: Reference dipole = 0 db

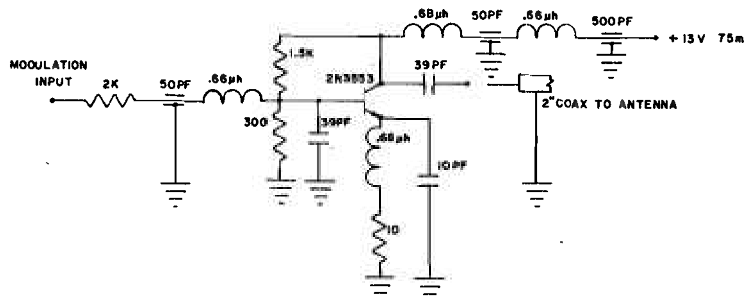
Figure 4. Transverse ladder ring antenna elevation pattern.

V = 13 V I = 90 m
POWER OUT 300 mw F = 254 MH_z
2N3553 TRANSISTOR



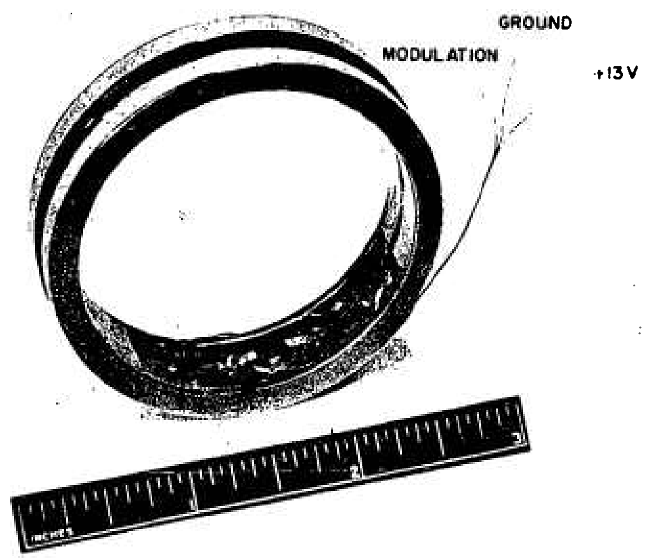
1- POWER METER BOLOMETER
2- 20db ATTENUATOR
3- ADJUSTABLE SHORTED STUB
4- BIAS INSERTION UNIT
5- ADJUSTABLE 50 ohm LINE
6- TRANSISTOR MOUNT
7- BIAS INSERTION UNIT
8- ADJUSTABLE STUB

Figure 5. Coaxial oscillator



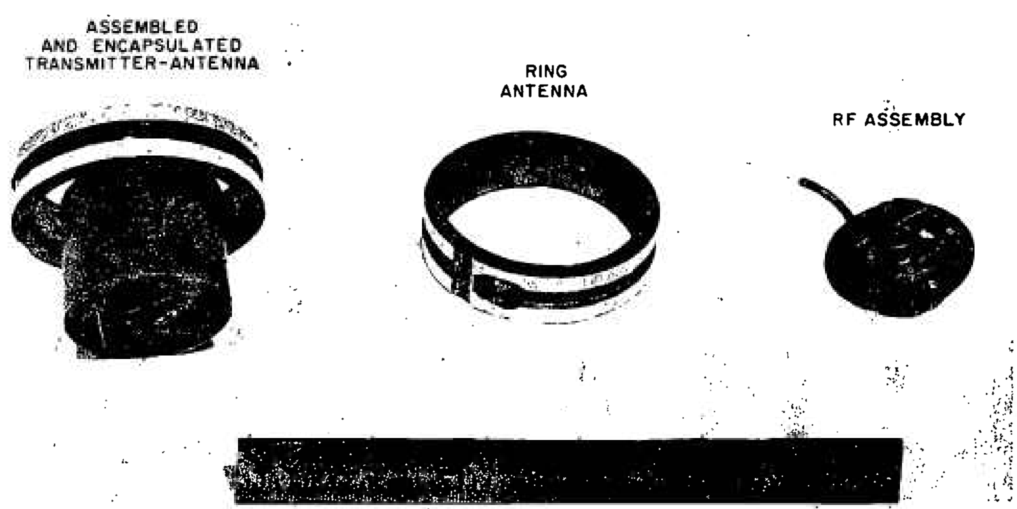
F_0 = 258 MH_z

Figure 6. Lumped parameter oscillator circuit



286-67

Fig. 8 Integrated Antenna-transmitter Assembly.



1838-66

Fig. 7 Antenna-Transmitter Assembly.

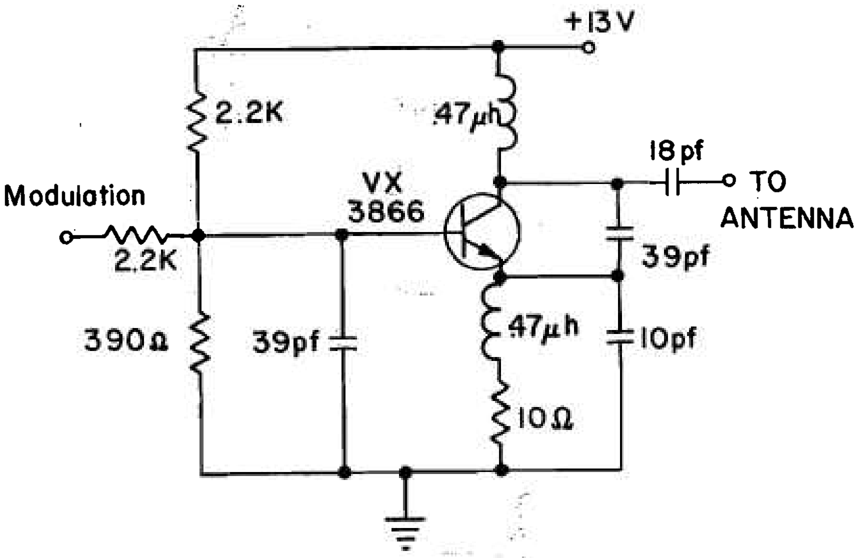


Figure 9. Integrated antenna-transmitter circuit.

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author): Harry Diamond Laboratories, Washington, D.C. 20438	2a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED 2b. GROUP

3. REPORT TITLE: A FUZE-TELEMETRY ANTENNA-TRANSMITTER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name): Bassen, Howard

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1967	22	1

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. DA-1N222901A301	TR-1343
c. AMCMS Code: 5221.11.62500	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d. HDL Proj 56500	

10. DISTRIBUTION STATEMENT: Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command

13. ABSTRACT

An integrated antenna-transmitter was developed to telemeter data from inflight artillery fuzes with minimum modification of either fuze or shell. The strip transmission line antenna provides a wide, uniform radiation pattern while providing stability to a rugged and easily fabricated VHF transmitter. Incorporation of the antenna as the tuned circuit of the oscillator stage of this FM transmitter proved to be the optimum utilization of this compact ring antenna.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Telemetry transmitter						
VHF transmitter						